Final Report

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Investigation of the Atmospheres of the Outer Planets

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by

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Model Studies

This project has focused on the Saturnian upper atmosphere and ionosphere and their interaction with the rings. The work has been primarily theoretical in nature, and has involved the development and use of several different types of computer models. The following is a summary of each of the five major tasks dealt with in this work.

1. **Global Ionospheric Conductivities.** Global ionospheric, height integrated, Pedersen conductivities were calculated using ionospheric electron density profiles obtained from spacecraft radio occultation experiments, inferred diurnal variations in peak electron density obtained from analysis of Saturn Electrostatic Discharge (SED), and results from an early ionosphere model. Some of the results of this work were published in *Cheng and Waite* [1988] where the consequences of the resultant conductivities for magnetospheric circulation and ionosphere atmosphere coupling were discussed.

2. **Water Meteoroids in Saturn's Upper Atmosphere.** A model describing the passage of water rich meteoroids through Saturn's hydrogen atmosphere was developed. The model includes the effects of sputtering and sublimation as the meteoroids are heated and slowed during their descent. From this work it was found that these meteoroids deposit most of their water below an altitude of 1000 km and that most of the water deposited above 1000 km is produced by meteoroid sputtering. Some of the results of this work were incorporated in a paper on the ionosphere of Neptune [*Shinagawa and Waite*, 1989].

3. **Time Independent Ring Ionosphere Plasma Coupling.** A steady state kinetic plasma transport model used in the study of terrestrial polar plasma outflow was modified to model the flow of plasma from Saturn's ionosphere to its rings, and the interaction of warm ring plasma with the cool ionospheric plasma. Results of the study suggest that warm ring generated plasma will be centripetally trapped near the outer B and A rings and will exclude ionospheric plasma from these regions. A significant flux of ring generated plasma from the B ring can reach the ionosphere and plasma from the ionosphere can flow to the C and D rings. These results were published in the Journal of Geophysical Research [*Wilson and Waite*, 1989] (see attached reprint) and presented at the 1989 spring AGU meeting.

4. **Time-Dependent Ring Ionosphere Plasma Coupling.** Because of the large diurnal variation in the peak ionospheric electron density in the equatorial ionosphere it was recognized that the plasma density near the C and D ring probably also showed a large diurnal variation. A time-dependent kinetic plasma transport model was developed to study this situation. Some of the results of the model are shown in figure 1 where the H^+ density and mean energy in the ring plane are plotted. The charge state of the C ring was found using these results. This work was presented at the 1990 spring AGU meeting and a paper to be submitted to JGR is in preparation.

5. **Ring Charging Studies.** Being immersed in ionospheric and ring generated plasma the rings will be electrically charged to some potential. A model previously developed, was used to study how the charge and electric fields in and around a ring dust cloud depend on the ambient plasma conditions and the ring optical depth. These results were presented at the third workshop on the physics of dusty plasma in October, 1988 and later published in JGR [*Wilson*, 1988] (see attached reprint). In doing this work it was discovered that there will be electrostatic oscillations within the ring after it has charged up, and we have begun to study these oscillations. This work will be presented at the fourth dusty plasma workshop in September, 1990.

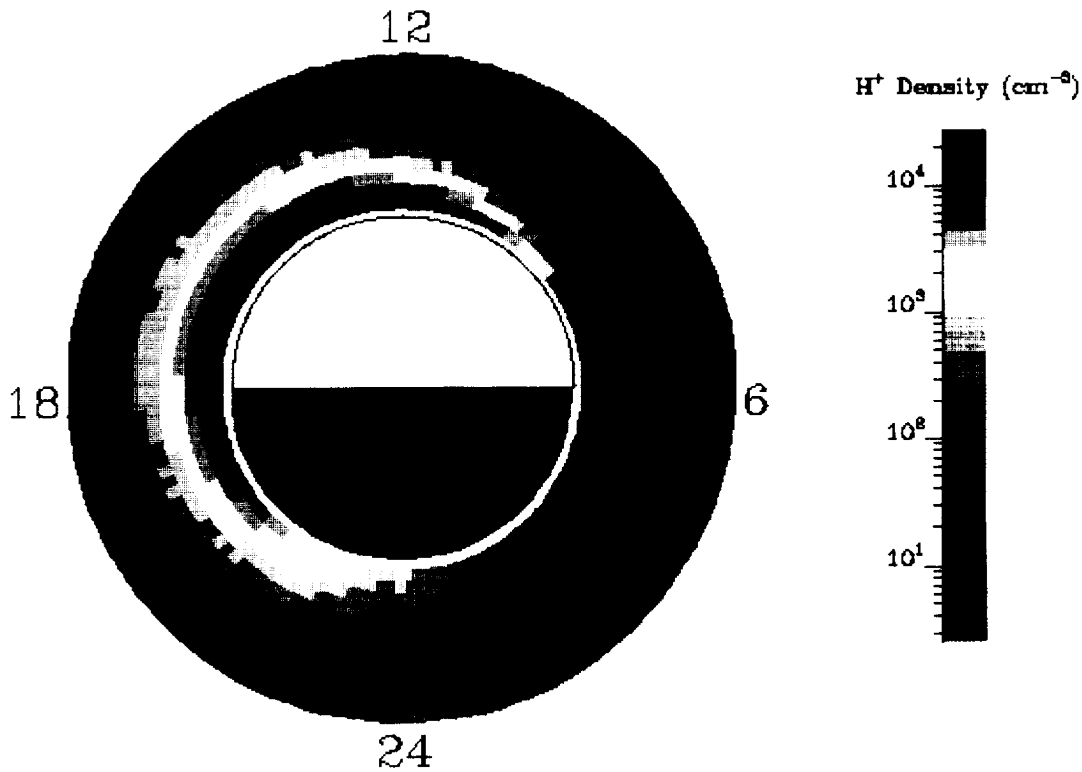
Papers Published

Cheng, A. F., and J. H. Waite, Jr., Corotation lag of Saturn's magnetosphere: Global ionospheric conductivities revisited, *J. Geophys. Res.*, *93*, 4107, 1988.

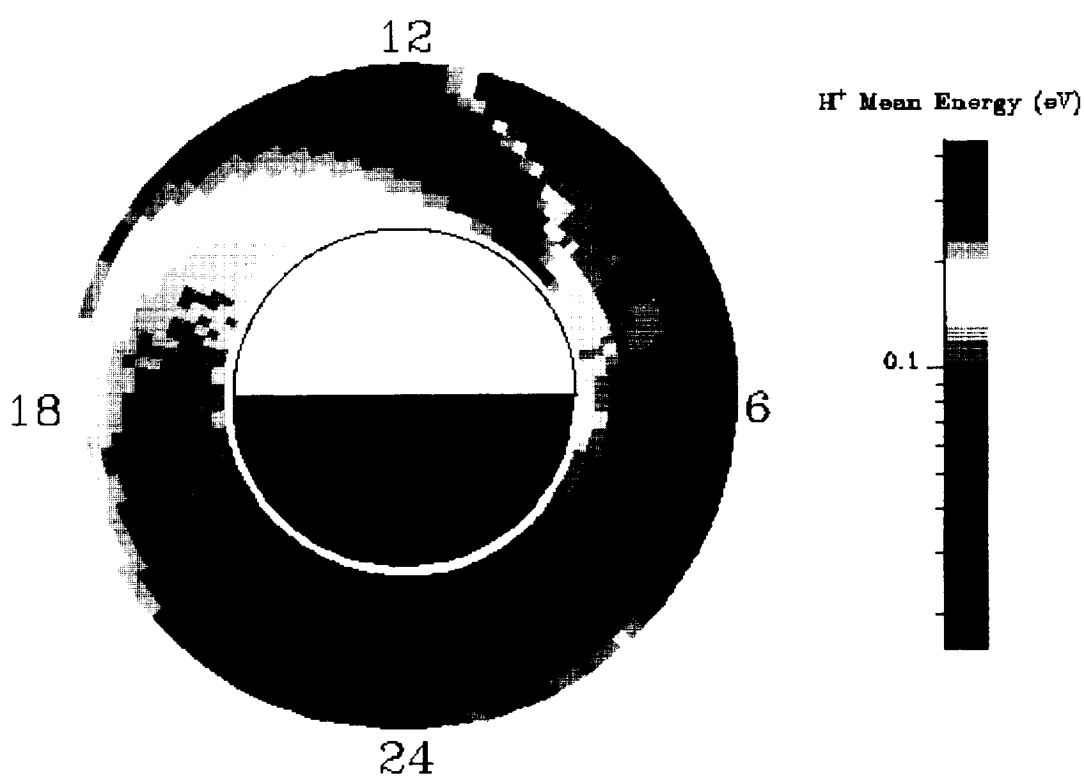
Wilson, G. R., The electrostatic charging of thin dust clouds, *J. Geophys. Res.*, *93*, 12771, 1988. (see attached reprint)

Shinagawa, H., and J. H. Waite, Jr., The ionosphere of Neptune, *Geophys. Res. Lett.*, *16*, 945, 1989.

Wilson, G. R., and J. H. Waite, Jr., Kinetic plasma modeling of the Saturn ring-ionosphere plasma environment, *J. Geophys. Res.*, *94*, 17287, 1989. (see attached reprint)



12
18
6
24
H+ Density (cm-3)
10^4
10^3
10^2
10^1



12
18
6
24
H+ Mean Energy (eV)
0.1

Figure 1

Papers in Preparation

Wilson, G. R., The plasma environment and charge state of Saturn's C and D rings, to be submitted to *J. Geophys. Res.*, 1990.

Papers Presented at Meetings

Wilson, G. R., The electrostatic charging of thin dust clouds, Presented at the Third Annual Workshop on the Physics of Dusty Plasma, Lawrence, Kansas, October 1988.

Wilson, G. R., Kinetic modeling of the Saturn ring-ionosphere plasma environment, AGU spring meeting, *EOS Trans. AGU*, *70*, 452, 1989.

Wilson, G. R., The plasma environment of Saturn's C and D rings and their charge state, AGU spring meeting, *EOS Trans. AGU*, *71*, 550, 1990.

Papers to be Presented

Wilson, G. R., The Saturnian ring-ionosphere plasma environment, to be presented at the Fred Scarf Memorial Symposium "Magnetospheres of the Outer Planets", Annapolis, Maryland, August 20-24, 1990.

Wilson, G. R., and D. L. Gallagher, Electrostatic oscillations in thin dust clouds, to be presented at the "Fourth Workshop on the Physics of Dusty Plasma", Iowa City, Iowa, September 11-13, 1990.